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ABSTRACT

Elementary science teachers allow an average of one second for a response to a question, and follow a student response by a comment within an average of nine-tenths of a second. When these two "wait times" are extended to three to five seconds, a number of changes occur in student variables. There are increases in the length of the response, the number of unsolicited appropriate responses, student confidence, incidence of speculative responses, incidence of child-child data comparisons, incidence of evidence-inference statements, frequency of student questions, and incidence of responses from "relatively slow" students. The number of teacher questions which do not elicit a response decreases. Teacher characteristics change as wait-times increase. There is an increased flexibility of teacher responses, the questioning pattern becomes more variable, teacher expectations for performance of students rated as "slow" may change. These generalizations are based upon five years of study of video-taped lessons or micro-teaching sessions. These studies also suggest some research hypotheses concerning the effect of verbal reward and wait-time on students' perceptions of their degree of environmental control: low incidence of verbal reward and a long wait-time may reduce fatalism. (Author/AL)

ABSTRACT

TITLE: WAIT-TIME AND REWARDS AS INSTRUCTIONAL VARIABLES: THEIR INFLUENCE ON LANGUAGE, LOGIC, AND FATE CONTROL.

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ABSTRACT: The paper summarizes work of five years on influence of a variable called teacher wait-time on development of language and logic in children taking part in elementary science programs. Analysis of over 300 tape recordings showed mean wait-time to be on the order of one second. After a teacher asks a question students must begin a response within an average time of one second. If they do not the teacher repeats, rephrases or asks a different question or calls on others. A second potential wait-time is involved. When a student makes a response, the teacher reacts or asks another question within an average time of 0.9 seconds.

When mean wait-times of three to five seconds are achieved through training, analysis of more than 900 tapes shows changed values on nine student variables: 1. The length of responses increases. 2. The number of unsolicited but appropriate responses increases. 3. Failures to respond decrease. 4. Confidence as reflected in decrease of inflected responses increases. 5. Incidence of speculative responses increases. 6. Incidence of child-child comparisons of data increases. 7. Incidence of evidence-inference statements increases. 8. The frequency of student questions increases. 9. Incidence of responses from students rated by teachers as relatively slow increases.

Servo-chart plots of recordings show that students discussing science phenomena tend to speak in bursts with intervals of three to five seconds between bursts being fairly common. The average post-student response wait-time of 0.9 seconds apparently intervenes between bursts to prevent completion of a thought.

Over time a classroom on the prolonged wiat-time schedule takes on other properties. Three teacher variables change: 1. Response flexibility scores increase: 2. Teacher questioning pattern becomes more variable: 3. There is some indication that teacher expectations for performance of students rated as relatively slow improves.

A model which involves the relation of wait-time and reward as input variables to language, logic, and fate control as complex outcome variables is discussed.

WAIT-TIME AND REWARDS AS INSTRUCTIONAL VARIABLES: THEIR INFLUENCE ON LANGUAGE, LOGIC, AND FATE CONTROL[1]

by

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"The paradigm observer is not the man who sees and reports what all normal observers see and report, but the man who sees in familiar objects what no one else has seen before."

-Norwood Russell Hanson
in Patterns of Discovery

Introduction

All of the major elementary science programs extant today were designed to provoke children to inquire about relationships among natural phenomena. All of them provide situations meant to be suitable for the development in children of certain skills and a viable knowledge structure. In spite of provocative stimuli, the people who prepared the programs had to admit that the amount and quality of inquiry actually occurring fell well below expectations. While some people connected with the projects blamed the situation on the teachers' lack of science knowledge, certain observations made by me and those working in my group made us think that this generally held explanation was too superficial. The evidence we had, though fragmentary, did not support that view.

We found, for example, that children taught by teachers with considerable training in one of the programs did not exhibit substanially different rates of inquiry from those taught by teachers with less exposure to the programs. Neither were we able to distinguish different patterns of inquiry in one program as compared with another. With a few marked exceptions which will be discussed shortly, the quality of discourse tended to stay at a low level and the pattern of interchange between teachers and children still more slosely resembled an inquisition than a joint investigation or a reasonable conversation.

That we could further discount the "lack of knowledge" argument as a primary factor seemed to be demonstrated in data from two conferences funded by the National Science Foundation in which we had the opportunity to compare the instruction of children as carried out by a total of 54 scientists and

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In addition, a post-doctoral appointment at New York University had permitted the author to spend more time on investigations than would be possible when carrying a normal professional load. The appointment was funded through the United States Office of Education.

science educators with instruction as conducted by a sample of classroom teachers. It was clear that some factors other than knowledge differences must be at work because the patterns of questions and responses were remarkably alike. To make that determination, we conceptualized the classroom as a two-player system consisting of a teacher and the collection of students (treated as the other player). Teachers had four kinds of verbal moves available to them--structuring, soliciting, responding, and reacting or evaluating. In theory, students engaging in inquiry would have the same set of moves available to them. By simply categorizing the sequence of moves and plotting them approximately on a time line, the patterns of interaction could be clearly displayed. Figure I, for example, shows what the "inquisition" looks like. It is characterized by a rapid question-answer sequence with the solicitation coming usually from the teacher. Figure II, on the other hand, shows what an inquiry pattern or a conversational pattern looks like. In addition, we found that whatever pattern the teacher exhibited when working with four children closely resembled the pattern displayed when carrying on a discussion with a whole class of children.

The fact that the appearacne of one or two graphs made from recordings of micro-teaching sessions mirrored the form found for each teacher when working with a whole class suggested that size of groups could not be a major factor in determining whether an inquiry pattern would or would not develop. Thus we are left with none of the usual remedies for improving inquiry. We could not blame its low incidence on lack of materials, or on lack of knowledge, on program or on group size, at least not within rather broad limits.

Wait-Time

After visiting and recording examples of science instruction carried out in classrooms located in suburban, urban, and rural areas, it finally became clear that while different curricula served as the vehicle of instruction, almost all of the discourse had one stable property. With the exeption of a few individuals (three in two hundred recordings) the pace of instruction was very fast. Teachers allowed children an average time of only one second to start an answer to a question. If children did not begin a reply within one second, teachers usually either repeated the questions or called on others to respond. When children did respond, teachers usually waited slightly less than a second (average of 0.9 seconds) before commenting on the response, asking another questions or moving to a new topic.

In the few classrooms where inquiry was going on, the discourse was marked by the appearance in the speech of the children of speculation, conversational sequences, alternative explanations, and arguments over the interpretation of data. Such classrooms differed from the others in one respect; the average wait-times seemed to be slightly in excess of three seconds. It appeared that more of the desired inquiry behaviors occurred in classrooms where teachers had longer wait-times.

One other observation connected with wait-time caught our attention. We asked teachers to tell us who, in their judgements, were their five best and five worst students. When we examined the amount of wait-time given, on the average, to each group we found that the top five get nearly two seconds to answer while the bottom five get slightly less than one second (0.9 seconds).

This last small piece of inquiry alerted us to another variable, reward frequency, to which we had given no attention. The amount of sanctioning behavior directed toward the two groups differed. The bottom-ranked children

actually received more overt verbal praise than the top-ranked children but it was difficult to know with certainty what was being rewarded. The top groups received relatively less evaluative comment from their teachers but the rewards were usually more pertinent to the responses made by the children. The bottom groups gathered both more praise as well as more negative comment but its intent was far more ambiguous. It seemed that teachers rewarded the top groups for correct responses but they rewarded the bottom groups for both correct and incorrect responses. Presumably the intent of some of this reward behavior must be to encourage participation.

We guessed that a clear teacher expectation pattern develops early in the history of each classroom. Differences in the wait-time and reward patterns administed to children ranked at the top as compared with those at the bottom suggest that teachers unconsciously act in such a way as to confirm their expectations.

So we came to focus our attention on two imput variables, wait-time and reward. This paper will focus on wait-time but it will be necessary to comment briefly on the possible effect of sanctions so the reader will understand why this variable had to be brought some what under control.

Reward

Exploration and inquiry require students to put together ideas in new ways, to try out new thoughts, to take risks. For that they not only need time but they need a sense of being safe. Sanctioning behavior, no matter how well intended, carries with it an implicit message: "Big brother will get you if you don't watch out." Judgement by an external source which often behaves whimsically in the view of children cramps investigation.

To grow a scientific think SYSTEM takes time and a great deal of shared experience, free of the notion of cheating and the fear of teacher reprisal in the form of verbal pats or paddles. It is in talking about what we have done and observed and in arguing about what we make of our experiences that ideas multiply, become refined and finally eventuate in new questions and experiments. It is in preserving for ourselves the right to be wrong that we gain courage to try out new ideas, to explore more alternatives, to objectively evaluate our own work as well as that of others. The new science programs depend heavily on an intrinsic rather than an extrinsic motivation model. Conceptual conflict is meant to drive inquiry along just as it does in the scientific enterprise.

We begin to suspect then that at least when we wanted children to engage in problem solving behavior, in contrast to skill acquisition, wait-times should be high and reward schedules should be reduced. High rates of rewarding would undermine confidence and act as distractors. In addition, it might encourage premature termination of search, a disposition to choose the first alternative that comes to mind. Certainly it would discourage sharing of ideas between students since then someone else could walk off with praise for a performance first carried out by another child.

Simulation Studies

In an attempt to understand something of the effects of reward and wait-time on problem solving behavior of students, two simulation studies were undertaken. In connection with our interest in reward, F.X. Lawlor gave a problem solving task to children under circumstances that simulated reward patterns common in classrooms.(1) One group of children received overt verbal rewards on a random schedule. The random schedule comes closest to matching what had been observed to occur in classrooms. A second group of children received reward for correct responses, the pertinent reward condition. A third group of children received no overt verbal rewards as they worked. Lawlor found the problem solving efficiency of the group which received the ambiguous reward treatment to be significantly below the performance of the other two groups. Boys prospered in the no reward condition while girls fared slightly better on the pertinent reward condition. Lawlor's work lent impetus to our earlier supposition that in problem solving situations or inquiry situations, reward may function to distract students from the task.

D. Ogunyemi carried out another simulation which had as its intent an attempt to learn something about the function of listening in discussions of simple physical phenomena. (2) Students brought up under a fast wait-time schedule coupled with an ambiguous reward schedule probably do not get much from listening to each other. They are trained to hear the teacher, if they hear anything. When students are asked to report what they observe, as is the case in classroom discussions about science phenomena, those who actually do the talking may get some reinforcement. Does discussion benefit them or the rest of the class members?

Ogunyemi exposed individual students to a matrix problem that involved the use of colored dowels of different dimensions. One treatment group examined the matrix but did no talking about it. In addition to whatever they observed on their own they heard a tape recording of other students talking about their observations. Another treatment group , after observing the matrix, heard a teacher and students discuss it. Members of the third treatment group were encouraged to state all their observations. All three were then given a set of tasks to do involving the matrix. Ogunyemi thought that the opportunity to verbalize might improve the scores of students but he did not find that to be the case. What he did find was what we had suspected, namely, that students with a history of fast wait-time instruction tended to ignore information supplied by other students. (Tape recordings had previously been made in classrooms from which Ogunyemi's subjects came.) Again males responded womwhat differently from females. The females apparently listened to the teacher talk but not to the talk of other students. Males paid no attention to any source of verbalized information, if performance on the test tasks is taken as the indicator.

Circumstantial evidence leads to the inference that conversation in which students build on each other's ideas cannot develop in classrooms operated on a fast wait-time schedule.

Servo-chart Plots Show Several Species of Wait-Times

In micro-teaching situations we began to examine what happened when wait-times were experimentally manipulated. Since our earlier work showed that a group of four or more students makes a satisfactory model of the speech patterns to be expected of whole classes, this convenient approximation of the classroom discourse allowed us to gather a great deal of data fairly rapidly. Analysis of audio-and video-tapes immediately presented another problem to us. It became clear that our estimates of wait-time were too high. By the time the stopwatch was punched the discourse had moved on. We needed to find another way to measure wait-time that would not be hampered by the fact that motor responses (those necessary to actuate the clock) are very slow in comparison to mental responses.

This problem was partially solved by delivering the sound into a serv6-chart plotter. With a rectifier inserted between the tape recorder and the plotter, the needle could be made to track horizontally when there were silences. The paper for the plotter is calibrated. By running the the plotter as fast as it will go, each calibration comes to represent one second. As Figure III shows, the incidence of pauses as long as one second in a classroom where the teacher is not alerted to wait-time is very small. The height of the peaks simply indicates the amplitude of sound generated. One other interesting aspectof the plots is worth noting before going on. Children generate speech at a slower rate, on the average, than teachers do. This will be reflected in the plots by the width of the curves somewhat below the peaks.

Close examination of the servo-chart plots explains to some degree the dynamics involved in some of the outcome variables described below.

Species of Wait-Time

a. The two-player model: (See figures ___ and ___)

Instruction was conceptualized as a game in which there are two players. The teacher is one player and the set of students constitutes the other player. Four kinds of moves are available to each player.

1. Structuring in which a player gives directions, states procedures, suggests changes. (e.g., "Let's put the thermometer in the ice water.")

2. Soliciting in which a player asks a question. (e.g., "Why do you thing that happened?")

3. Responding in which a player answers a solicitation or responds to a structuring suggestion or builds on the response of another player or reports data. (e.g., "When I put the thermometer in ice water it went down to 4 degrees.")

4. Reacting in which a player evaluates statements made by other players. It includes verbal rewards and punishments. (e.g., "good," "fine," "OK," "that is not right," etc.) as well as appraisal (That doesn't work the way you said because the light is on.").

5. Wait-time locations - Examination of servo-chart plots show that wait-times during discussions may occur in the following locations:
   a. After a teacher move.
   b. After a student move
   c. In the body of a student move

Student talk, especially attempts at explanations, frequently comes in a series of bursts separated by pauses that often equal or exceed three seconds.

Figures 3a and b show the locations of the potential pauses in a sequence.

Figure III shows one example of a servo-chart plot typical of hundreds of tape-recordings where wait-times are short, i.e., under three seconds.

Species are on the order of one to two seconds or less. All the interactions go on very rapidly. Student responses tend to be short, averaging 6 to 10 words, and fragmented. It turns out that when students are allowed to speak to each other, as they do in a laboratory setting, or as they do when there si sufficient wait-time of species #2, allowed by the teacher, or as we have allowed it under experimental conditions, their speech tends to come in bursts. That is, any given child will put out an idea and in the body of his discourse there will be pauses which are often well in excess of one second, more like three to five seconds. (See figure IV) Apparently the reason for the high incidence of phrase-like rather than propositionalresponding that marks classrooms with short average wait-times is brought about by the intervention of the teacher between the speech bursts. Examination of data from the chart plots caused a shift in

our focus to the second wait-time the post-student response wait. Prior to the use of the servo-chart plotter we had paid most attention to the first species of wait-time, the amount of time teachers gave to students to begin an answer. The chart plots showed us that the second wait-time, the one which is potentially available after a student response, might account for even more variance in the outcome variables. If the teacher "held on" after a speech burst, then the incidence of extended explanation and the occurrence of alternative interpretations tended to increase. Figure IV, shows what typical speech bursts look like when delivered by a student trying to explain something he experienced with his science materials if he is left uninterupted. Mapping experience into language is an arduous process. Cutting off those pauses probably discourages expression and practice of propositional thought.

When a teacher first begins to experiment with wait-time, species 2, post student response is difficult to influence. The teacher tends to react very quickly and so do students. Students call out answers. There are few examples of what might be called a discussion (conversation) in which students respond to ideas introduced by other students. (See the discussion on training techniques.) After a time, however, this pattern gradually changes and the between-student pauses increase. Figure V should be contrasted with Figure III. It illustrates both the change in species 2 pauses and the increase in the length of student statements. (See Appendix A for a sample of transcript which illustrates the conversational rather than the inquisitional mode.)

Student and Teacher Outcome Variables

In the series of investigations to be described below the following outcome variables became the focus of attention.

a. Student Outcome Variables

1. The length of student responses increased. Under a fast schedule, responses tend to consist of short phrases and rarely exhibit explanation of any complexity. Data from the chart plots suggest that the second wait-time, when it is prolonged, contributes measurably to the appearance of longer statements.

2. The number of unsolicited but appropriate student responses increases. This outcome is more responsive to the second than the first wait-time, but is influenced by both.

3. Failures to respond decreased. "I don't know" or no responses were often as high as 30% in normal classrooms, i.e., in classrooms where the mean wait-time fell at one second or less. This outcome is more susceptible to manipulation by the first wait-time, the pause which the teacher allows before calling on another student or repeating the question. (It also happens to be responsive to reward incidence.)

4. Confidence as reflected in fewer inflected responses increased. Under a fast schedule, responses tend to be phrased as though the child were saying, "Is that what you want/" In the middle of a prolonged fast sequence you can ask a child his name and it will not be unusual to have him respond with a question mark in his tone. This confidence indicator, inflected responding, is also susceptible to the reward variable. As reward increases so does the incidence of inflected responses.

5. The incidence of speculative thinking increased. This is influenced by both classes of wait-times.

6. Teacher-centered show and tell decreases and student-student comparing increases. Under a fast schedule and a high reward or sanctioning schedule, children "stack up" waiting to tell the teacher. There is very little indication that they listen to each other. This variable will not be examined in detail in this paper since it seems to be influenced as much by the reward pattern as by the pacing.

7. More evidence followed by or preceded by inference statements occurred. Under a fast schedule, the incidence of qualified inferences is extremely low. When the second wait-time is lengthened this outcome variable changes in a desired direction.

8. The number of questions asked by children increased and the number of experiments they proposed increased. It is a well established fact from classroom interaction studies that students do not ask questions very often. When they do, the questions are usually for clarification of procedures and are rarely ever directed at other students. This outcome variable seems to be susceptible to both classes of wait-times.

9. "Slow" student contributions increased. Under a fast scheudle most responses came from a particular faction of the class. When wait-times were increased, the sources of response became more varied. Interestingly, this outcome gradually (apparently) influences teacher expectations. (Although we have not had time to investigate it in any detail yet, it seems to be both surprising and rewarding to the teachers that students who do not usually respond as readily begin to do so.)

b. Teacher Outcome Variables

Once wait-time is changed and the behavior is stabilized for a period, certain characteristics of teacher input variables change. They are regarded here as outcome variables because they are influenced by the wait-time factor.

1. Teachers exhibit greater response flexibility as indicated by the occurrence of fewer discourse errors. Under a rapid schedule, the normal situation obtaining in classrooms, the probability that a detectable discontinuity in the discourse occurs increases. Conversation does not build into structural propositions. Instead the sequence of discourse resembles a smorgasbord line in which everyone goes along commenting on what he passes and picks up but nobody pays any attention to or gives any indication that he has heard the comments of others. If a teaching machine asks a question and a student responds with something that is not in storage, the machine either goes on to the next question as though nothing happened or it cycles back and repeats, sometimes with progressive cuing. In either case a "discontinuity" is scored against the discourse. Our tapes suggest that frequently the teacher on a fast schedule achieves a less favorable flexibility score than does a moderately good computer program. At least the computer program has the advantage of leaving the response time up to the student. The flexibility score increases with increases in wait-times. It is computed by simply counting the mismatches between a student statement and a teacher response or reaction. (See appendix A for an example of discourse in which there are mismatches.)

2. Number and kind of teacher questions changes.

   a. The total number of questions decreases per a fifteen minute interval. Prior to wait-time training it was not usual to find as many as seven to ten questions asked by the teacher per minute! The mean number of questions averages between two and three per minute. (Inner city rates tend to be slightly higher than suburban rates. Samples of tape recordings made in the Cumberland Mountains, in Louisiana and in North Carolina show mean rates of 2.2 questions per minute.) As wait-times increase the rate of questioning drops. For teachers who have achieved criterion wait-times of three seconds or longer mean question rates tend to approach 0.4 per minute. This follows from the fact that student responses become longer; unsolicited student responses increase; there are more pauses between speakers as well as within the speech of speakers.

   b. The net variability in teacher questions increases as teachers achieve criterion wait-times of three seconds. Figure V. shows how the pattern of questions changed for a sample of 74 teachers who achieved criterion wait-times of three seconds or longer.

3. Teacher expectations for performance of certain children seem to change. In micro-teaching situations, we grouped children whom teachers did not know into pairs consisting of two children rated by their school as high verbal or two rated as low verbal or we paired one high with one low verbal. We told the teachers they had one of these combinations and the task was to do some science and employ a longer wait-time; then they were to judge with which kind of combination of children they were working. At the end of 20 minutes they made their judgements. They tended to make the

following kinds of errors:

a. They rated a high and low combination as two highs;
b. They tended to rate two highs correctly most of the time but occasionally rated them as a high and a low;
c. Two high verbals were occasionally (about 15% of the time) evaluated as a high and a low.

The fact that 26 teachers who identified their five best and five poorest students gave the best students more time to reply to questions leads one to suspect that the relationship of wait-time to expectations should be investigated in more detail. At the moment all we have accumulated over the last five years are unsolicited comments from teachers on longer wait-time schedules that members of the bottom group perform in new and surprising ways. That teachers may modify expectations gradually is indicated by comments about a student such as, "He has not done anything like that before. Maybe he has a special aptitude for science." It may be useful to study the influence of wait-time and rewards on teacher expectations in a more systematic way. We have not had an opprotunity, however, to discover whether the effect on expectations is general or how long it persists. Neither do we know how it may change the real performance of the students rated at the bottom of the class, given that the pattern of responding could be sustained.

Types of Wait-Time Investigations Pursued.

Over the last six years the investigations of wait-time have been quite varied in form as befits applied research where the primary goal is producing desirable outcomes in operating systems.

In vitro studies - The variable was identified first through regular observations of 36 primary grade classrooms in six schools in which the Science Curriculum Improvement Study (SCIS) was being taught. Six (+) tape recordings were made in each of the rooms during the years. (A total of 103 tapes) Once the fact of short wait-times, high question frequency and rewards was recognized it became a metter of interest to determine how general the phenomenon was. It could be the case, after all, that something about SCIS prompted the inquisitional pattern or that the pattern was unique to primary grades or that speech in the region of the six schools (New York and New Jersey) was always fast-paced. In the following year we collected 84 tapes made in classrooms scattered around the country where SCIS as well as other science curricula were being taught. Wait-times typically fell below three seconds. A sample of 34 tapes made of fourth grade classrooms showed mean wait-times to 1.3 seconds and only one outcome variable to be significantly different. The mean length of student responses was 14 rather than 8 words. Thus it seemed safe to infer that short wait-times were not localized in forst and second grade classrooms. In addition there are accumulated a miscellaneous collection of tapes sent by teachers who have begun to experiment on their own with the wait-time variable. In recent years tapes of fourth, fifth and a few high school groups show mean

wait-times to be well under 3 seconds, ranging from 1 second to 2.8 seconds.)

Micro-studies - In order to study the influence of prolonged wait-times which did not seem to be occurring with sufficient frequency in natural settings a series of micro-studies was begun. These took two forms:

a. The staff worked with small groups of students, finally settling on four as producing a reasonable facsimile of a classroom. Here the effort was to increase wait-times and to study the effect on the outcome variables described earlier. Both audio and video tapes were used. Students came from different grade levels and the lessons were selected from various curricula. Here the effort was to attempt to identify the relative influence of the two species of wait-time, the pause occurring after a solicitation and the pause following a student response. We attempted to manipulate these independently. Thus the same lesson would be taught to different groups of children but the sequence of treatments would be as follows.

Treatment I	Standard Wait-times
Treatment II	Wait-time #1 long, #2 short
Treatment III	Wait-time #1 short, #2 long
Treatment IV	Both wait-times long

b. A pool of six lessons were prepared. 96 teachers engaged in a series of teach-twice cycles designed to get them to produce criterion wait-times of three seconds. They each taught the same four students in each cycle.

In order to minimize the influence of sequence of lessons, the six lessons were grouped into three sequences. One third of the group did each sequence. This decision would make it safer to infer that differences on the outcome variables, if there were any, could be attributed to the influence of the wait-time changes. The treatment sequence went as follows:

a. Base line tape. No instruction on wait-times prior to taping. Play back discussion of wait-time. Portions of the tape transcribed by the teacher.

b. Tape 2. Wait-times and outcome variables discussed. Portions of the tape transcribed by the teacher

c. Tape 3. Analyzed and techniques for getting control of the post-student wait-time discussed. (See training suggestions described later.)

d. Tape 4. Analyzed in the same way.

e. Tape 5. Analyzed in the same way.

f. Tape 6. Analyzed.

All tapes were transcribed, coded. Wait-times were measured, the outcome variables identified and their values determined.

Return to the classroom - Twelve teachers with criterion wait-times in the teach-twice cycles were studied and given help in the classroom. For a period of one year observations and tape recordings were made at approximately two week intervals (once a week for the first four weeks and then at longer intervals). In addition four other teachers elected to study the influence of wait-time in their own classes and to supply us with tapes and transcripts. A total of 74 tapes were accumulated in this phase.

Analyzing Transcripts

Figure VII a and b show a typical analysis of a transcript. In addition, the questions would be categorized according to two systems, one modified from Ashner and Gallagher (3) and the system developed by T.W. Parsons (4). The primary objective was not to study questioning *per se*, namely as an input variable, but rather to study teacher questions as an outcome variable. We were asking whether the pattern of question asking spontaneously changes as a result of increases in wait-time.

The Aschner and Gallagher categories were five in number:

1. Routine questions concerning procedures and structuring of discussion.

2. Cognitive memory questions

3. Convergent questions requiring the analysis and integration of given or remembered data.

4. Evaluative questions.

5. Divergent questions.

The Parsons' categories used were the following:

1. Rhetorical questions
2. Information questions
3. Leading questions
4. Probing questions

The latter categories proved more useful since they could be identified more easily by teachers and coding required less interpretation of intent. (Intercoder agreement for Ashner and Gallagher varied from 72% to 84%. For Parsons system agreement varied from 76% to 94%.)

Computation of Mean Wait-Time

As Figures 3a and b show pauses can occur in three locations. Wait-times for each of these locations were recorded separately. The sum of seconds for each species of pause was divided by the total number of occurrences for that species. This has the effect of weighting each category according to its frequency of occurrence. The overall mean wait-time was then computed from these means.

The studies summarized in this paper as well as the one reported by Garigliano show mean wait-times prior to training to be on the order of one to two seconds. Garigliano did not succeed in getting any of the people in his training group to criterion of three seconds or longer. However, his work verifies that most of the outcome variables are as described for wait-times which are short.

Values of the outcome variables begin to shift in a favorable direction once mean wait-times equal or exceed three seconds. (See, for example, Table I) Classes which are maintained on criterion for prolonged periods gradually change in a number of characteristics. Figure VIII shows the kinds of shifts typical of the 12 classes for which recordings were made over a period of 18 to 21 weeks. It should be noted, however, that in the second or third week there is a tendency for teachers to regress on wait-time. Apparently a gradual role shift occurs for both teachers and students. During this adjustment stage teachers will complain that they can no longer decide when to intervene. Once through this period, however, criterion times are generally sustained. Figure IX illustrates the set of inter-dependent relationships which seem to be involved. This model requires considerably more long term investigation. At the moment it serves to remind us that we are discussing a system which gradually changes over time on a number of dimensions.

SOme Related Variables In Need of Further Research

The model which is governing the research is shown in Figure IX. It includes input and output variables.

1. Process Facilitation

This phase of our work is not much developed. In response to the changed dynamics in classrooms where teachers are working under schedules of low rewards and extended wait-times, role relations change. Certain kinds of decisions that formerly belonged exclusively to the teacher shift gradually to the children. They now face the problem of getting the resources in their groups available, i.e., getting all the ideas out and evaluated. More organizational problems and interdependence stresses develop. The presence of science phenomena that provoke controversy creates a situation which is nearly ideal for teaching children how to maximize group productivity. (We are operating on a model of science as an argument driven enterprise.)

H. Wiethake has collected data for two years on samples of trained and untrained children. That work is still in progress but even in this preliminary stage of development, the data from Wiethake's tape recordings in AAS-SAPA classrooms suggest a highly facilitative function is being served

by process training. As a part of this stage of research, some work should be done concerning direct training of students to take time both to frame replies and to hear other student. (For example, a preliminary indicator of the effect of such training is the frequency of interuptions.)

2. Fate Control

We are postulating a relationship between the factors of wait-time, reward, process facilitation and an outcome variable called "fate control". Fate control is defined as the belief that events that happen to you or that may happen to you are in some measure under your own control. Things you do now have some consequence for how things will be at another point in time which is not yet reached. To do that kind of believing requires some view about the nature of the world. A capricious world acts against the development of that belief. The scientist, for example, cannot tolerate a totally whimsical world. If the world were capricious, prediction would be impossible. When prediction is impossible planning becomes irrelevant.

For very young children the world is essentially whimsical. They do not see much connection between today's events and those that happened on some yesterday. To predict tomorrow's events with some kind of confidence is out of the question. Magic and the gods (the latter may include any authority figure) govern their world. A modern technological society could never develop nor could it survive by operating under such a conception.

The conception of a chance, whimsical, potentially uncontrollable world eventually brings humans to the point of abdication from all attempts to cope or to change conditions around them. Planning becomes irrelevant since plans depend on some continuity between events and there is none under the "craps" model of the world. Think of fate control as a variable whose value depends on where in a continuum you stand. Suppose there are two kinds of people in the world, craps shooters and bowlers. The craps shooter lives totally in the present. If his luck is good he is happy and he feels "blessed". But the outcome of the game, given that the dice are honest, had nothing to do with him. When he shakes and rolls his fate rides on the dice. His future is left entirely to chance.

The bowler, on the other hand, knows that there is some indeterminacy when he throws the ball but he also knows that according to how he analyzes the situation and acts, he can increase the probability of a favorable outcome. He can discover ways to improve his score. In fact, when the ball leaves his hand, in contrast to the situatuion with the craps player, it carries a kind of "message" out into the environment from the player. The bowler stands relatively higher on fate control than does the craps shooter. He can dream of what might be and then begin to move toward it. But the craps shooter must live forever with what is. Childrenwho grow up under the craps model often arrive at the age of work unequipped to operate effectively as producers or consumers. From the work of Rotter, Lefcourt and others it appears that two people of comparable intelligence who stand at different positions on a fate control measure behave differently in problematical situations. The bowlers are more aggressive about collecting information and more insistent on exploring solutions than are the craps players. Bowlers act as though there is a way out. Craps shooters act as if there is no way out.

It is a matter of some interest, then, to see what in the school environment contributes to the development of children who believe and act as though their fates were, at least in some measure, under their own control. At the moment our speculation can be summed up in the following way:

In the presence of stimulating science materials, a low incidence of overt verbal rewards during inquiry sessions, protracted wait-times, and with some facilitation training, children who are craps shooters can become bowlers. At least that is an hypothesis worth evaluating.

The pertinence of the low reward schedule to the fate control variable should be obvious. If the usual classroom sanctioning behavior is both intense and whimsical, then the situation encourages craps. If wait-times are short rather than long, the sense of powerlessness that marks the craps shooter will be enhanced. Protracted wait-times, low overt verbal rewards and process facilitation training encourage development of bowlers. It is hoped that other researchers will join us in finding ways to operationalize the fate control variable.

3. Personality Variable

There has been some suggestion that a personality variable may be involved in the wait-time shift. One might postulate that persons scoring high on a dogmatism scale would tend to exhibit shorter wait-times.

Summary

Figure IX illustrates the set of relationships postulated in this paper. Three input conditions, wait-time, reward, process facilitation influence the values of three output conditions, language, logic, fate control. The changed values of the output conditions, in turn, alter teacher expectations. As teacher expectations change the input conditions take on new values. So the system is potentially dynamic. This paper has focused primarily on the influence of the wait-time variable on nine outcome variables.

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Much credit is due to Dr. Francis X. Lawlor who has taken part in these studies since their inception. Graduate assistants and classroom teachers who participated must also be credited. This kind of research is something done with people, not something done to them.

APPENDIX A

Some Training Techniques

a. Certain habituated verbal signals tend to interfere with the post-student response wait-time (species 2 wait-time). These need to be reduced or eliminated.

1. Mimicry in chich teachers repeat portions of what students say.

2. Yes . . . but . . . . constructions which signal rejection of an idea.

3. The command to "think" without providing either a pause or cues.

4. Evaluative comments such as "fine," "good," "ok," " . . . "right" following a student statement.

b. As teachers move around the room working with groups they tend to keep up a constant flow of talk. Techniques which seem to help increase wait-times of both species are the following:

1. Join the group with no comment at all. This is another version of wait-time. Become an observer of the phenomena the children are examining and talking about. Speak when you are able to make an observation or other statement about the system.

2. Join the group at its eye level. Pull up a chair or stoop down but get down to the head level at which the children are working. The video-tapes show children turning away from phenomena to speak to a teacher who is standing. This disengagement is avoided by "join up" at the common head level.

3. If it is necessary to ask a question, try to avoid asking one that begins, "Why did you . . . etc." Analysis of tape recordings shows that the probability of getting a response to a question in this form is considerably less (approximately 30%) than if the same information was requested in some other question format.

4. Lose eye contact. At first children try to mediate their arguments through the teacher. The flow of discourse directly from one child to another increases when the teacher loses eye contact with the speakers.

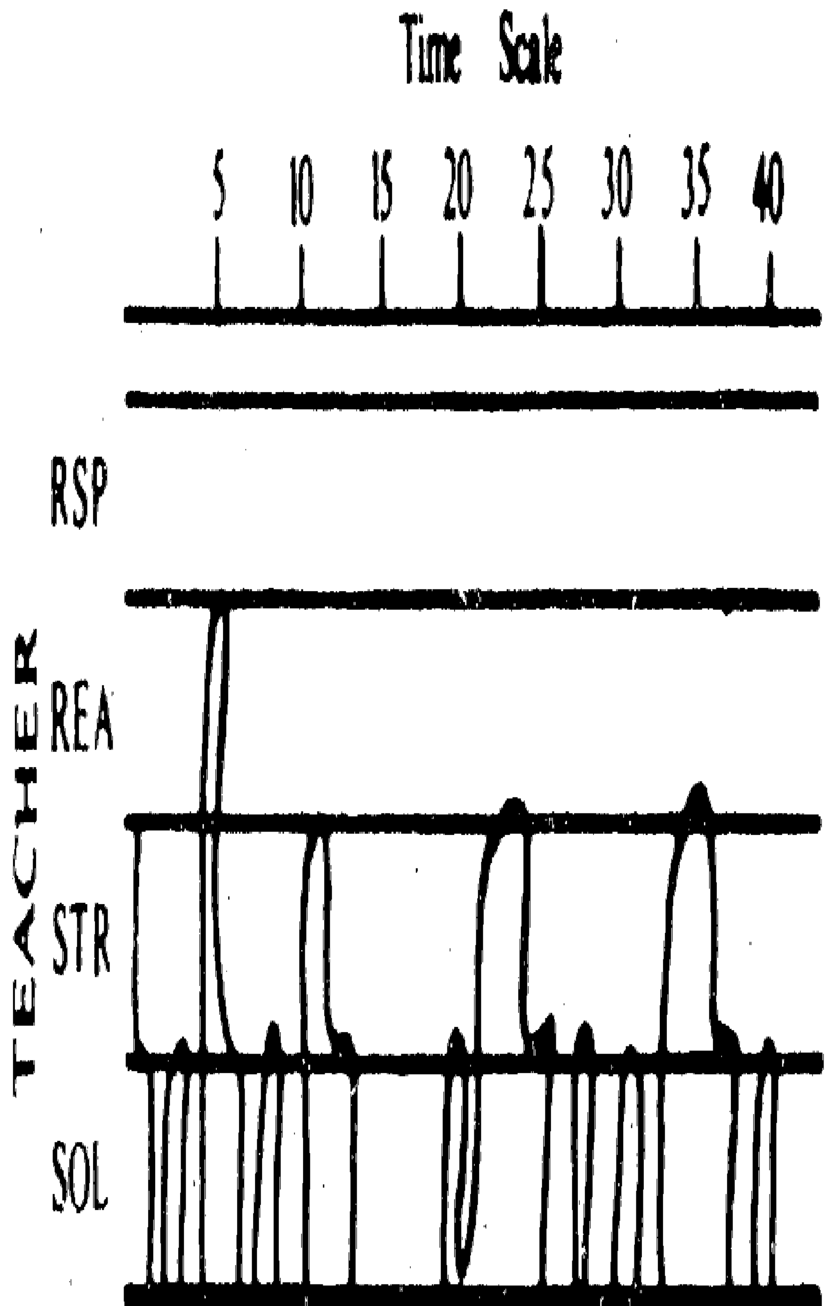
5. Make most comments, especially in the early stages of helping children to work collaboratively, on processes you observe going on between them. This process facilitation function need not be served exclusively by the teacher. The children can learn to provide the same service to their own work groups.

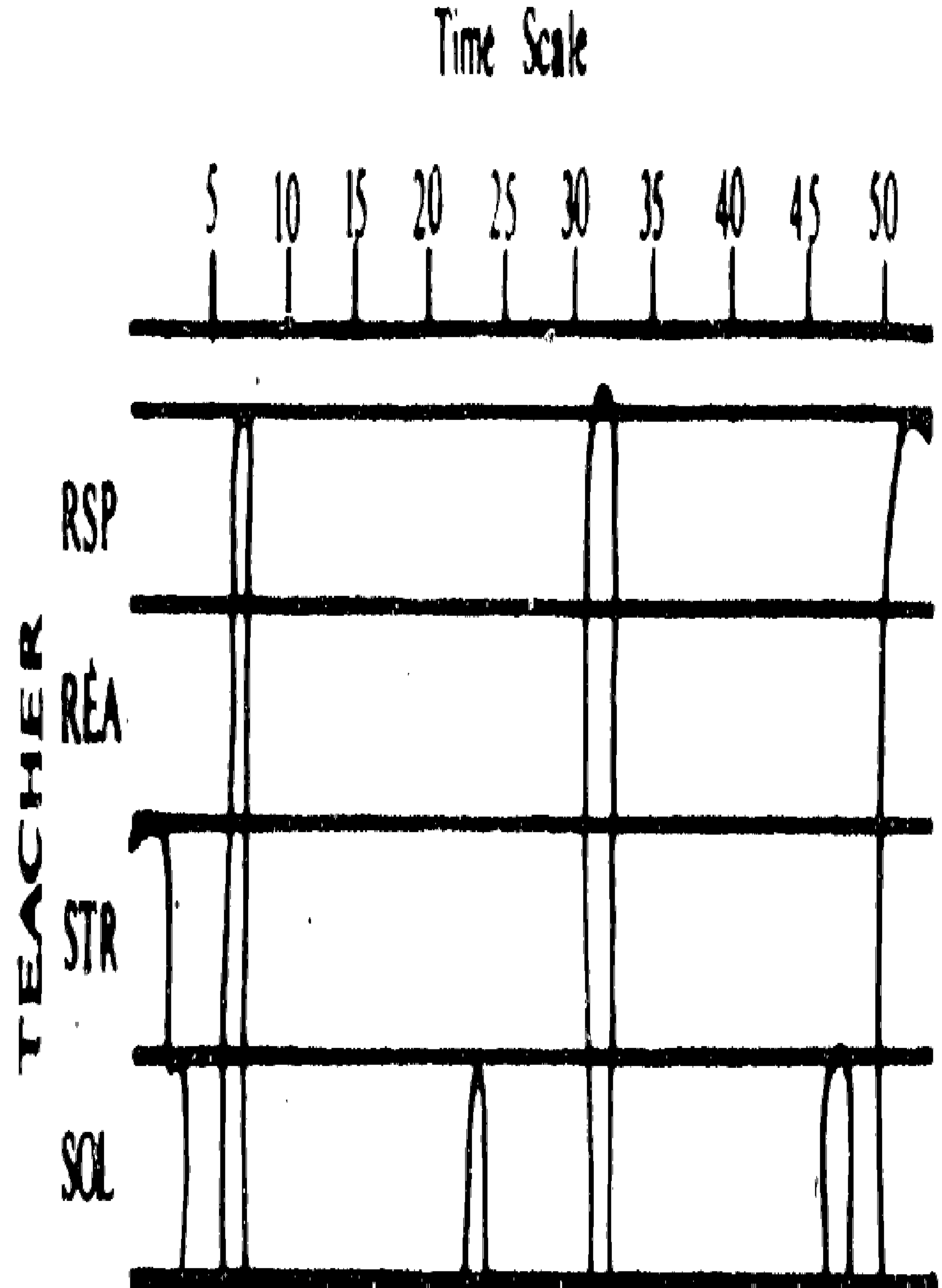
One of the process facilitation techniques has a close analog with skills being taught in the science program. It has two or three statements in it, depending on conditions. The speaker says:

"I observe	X."	Where X is any statement that he can make about the group, e.g., "I observe that someone interrupted Gregory every time he spoke."
"I infer	Y."	Where Y is an inference based on the observation X, e.g., "I infer that you are not interested in what he has to say."
"I feel	Z."	Where Z is a statement about how the observation-inference feels to you. "I feel you are missing some good ideas."

Some simple group skills training for children, seems to encourage productive discourse.

c. Support for the change. At about the end of the second or third week, teachers experimenting with wait-times appear to go through a period of frustrating indecision. They cannot decide when to intervene. If they do not receive encouragement in this interval their mean wait-times tend to dip back to pre-criterion values.


Time Scale
5 10 15 20 25 30 35 40
TEACHER
RSP
REA
STR
SOL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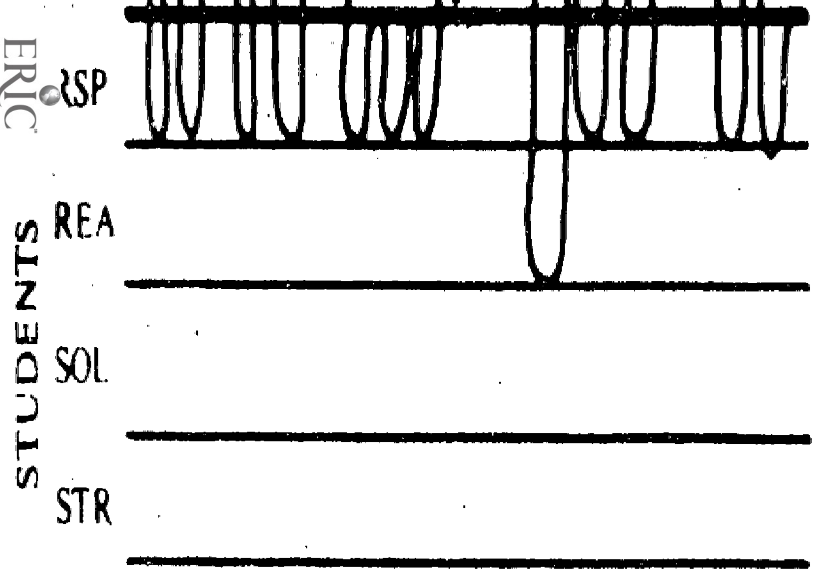


Figure I: The "inquisition".

Note: The heavy line separates the two players. The moves, soliciting (SOL), structuring (STR),, reacting (REA), and responding (RSP) are listed above and below the line according to their relative frequency of occurrence in the usual classroom pattern. Teachers do most of the structuring and soliciting and the students do the responding.

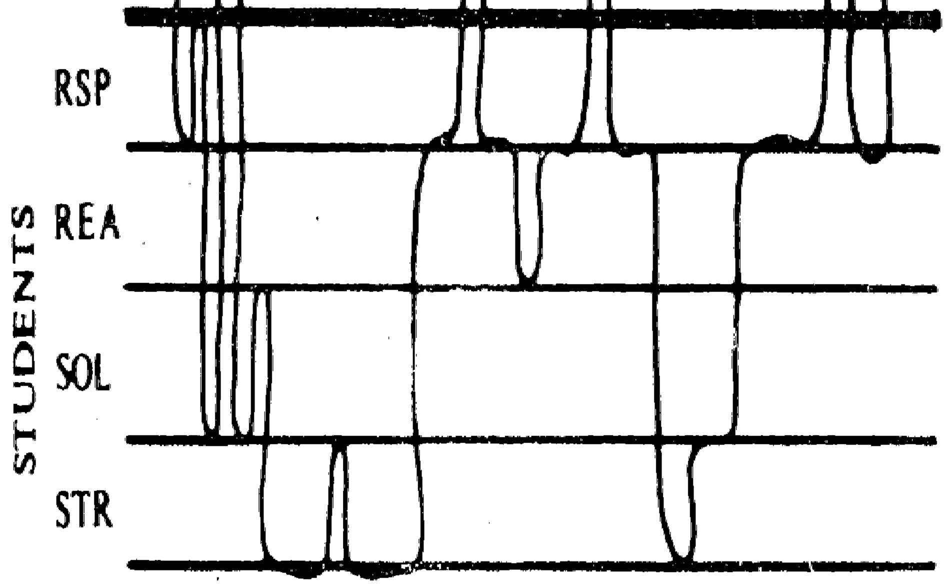


Figure II: The "conversation". In this pattern both players engage in all of the kinds of moves. Students begin to suggest experiments (structuring) or they converse and react to each other's statements (responding and reacting). In contrast to the inquisition pattern, more of the weight of the moves falls below the center line and the over all pattern exhibits more variety.

APPENDIX B

Sample Transcript

Mean Wait-time for this teacher exceeds 3 seconds. Portion of transcript shows how length of student responses increases as does the number of unsolicited but appropriate moves.

T. Yesterday we did some work with the blue print paper and light. What results can you see by looking at the various groups, papers, and what ever happened?

C. Amy, you don't want to do it now?

C. The Ah longer we let the Ah light hit it the darker it got. We had different times, most used time was 10, 5, 3. If it was 3 minutes that it was kept under, it was 5 minutes that came in between.

C. Well um one of the things that you'll. One of the um the three strips of paper um the results don't seem to Ah go along with what you said David because the 10, and the three are the same and the 5 is a little darker.

C. I disagree with you um because (um what David said was, well when you keep it under longer its gets darker, I support, agree with Davey, and I don't agree with you at all.

C. Well, Ah, in Ah some cases some people didn't exactly know what to do so Ah they could've made a mistakes and maybe put the whole slip in the, in the Ah light, in the pockets we put them in and therefore could not really tell that much.

C. Well I think at one point Ah theres a time where it gets the darkest, between 10 and 5 and then it seems to get lighter because when are things there it does look a little lighter than the five. So one point, I'm just guessing, but one point in between that probably would be the darkest point there and then it gets lighter.

C. I don't think it was supposed to get darker as it was exposed to light, because we did it and when we exposed it to light the color came off, but when you put it in water and you let it dry it got darker.

C. Well, most of them look the same, from here, not really all of them, but most of them, they all look pretty dark.

C. I think it was because the um light too if you have a dull um light it wouldn't show up to much and if you have it like a real bright light it will react more, like it'll get a shade that will be darker.

C. Well, I think the more time you have it under the light the darker the part that isn't under the light gets.

C. I disagree with you because uh it's the um side that is in the light gets darkest.

C. I agree with Kathy, because how could anything happen to the part ~~which-is-in-the~~ that like just isn't in the light. What happen to the part which is in the light?

C. I disagree with Kenneth because Ah he said that the part that was hidden from the light got darker, the part that was in the light got darker . . . . not hidden from the light.

C. Well I don't think the water really affected the color that much, I think it was just the light that did it, cause when we took it out you could see the difference already without putting it in the water.

C. Did it get any darker when you put it in the water?

C. Well

C. Well, not really.

C. Well, um what ... what, Kathy said, um. It really is true. It just gets a little feel of the water when you put it in the water. It gets a little clearer.

C. The thing that happened with ours was when we tested ours and we took it out, it didn't look like anything happened to it, and then when we put it in the dark and put a paper towel over it and left it over night it got much darker the next day. Like today, when we looked at it.

C. Well, um, some people walked around with the strips while they were getting ready to experiment. And then when they put it in the light they could of already been a little darker.

C. Well I . . . I agree with ____________ because when we did our experiment and everything. Um, when we tested it, ours turned out like, um white on the other side of it. And, um, then when we left it over night it turned dark.

C. Well I disagree with John, he said like before the experiment if we walked around with it, it wouldn't make any difference if we didn't dip it into water say got paper and we brought it up from the art room into Mr. Wiethake's room, does it get darker?

C. Yes but I disagree with Sal because thats different kind of paper Sal. And it might have an affect because we were keeping it in a book and it was dark there and as you were walking around the light could have affected it and its not the same kind of paper as the normal paper we get out of our notebooks so I agree with John.

Footnote: This transcript was f[illegible]nished by [illegible] W[illegible] [illegible]hake, a fourth grade science teacher who wa[illegible] investigating th[illegible] influence of wait-time. (SAPA program [illegible] series of lessons [illegible] controlling variables.)

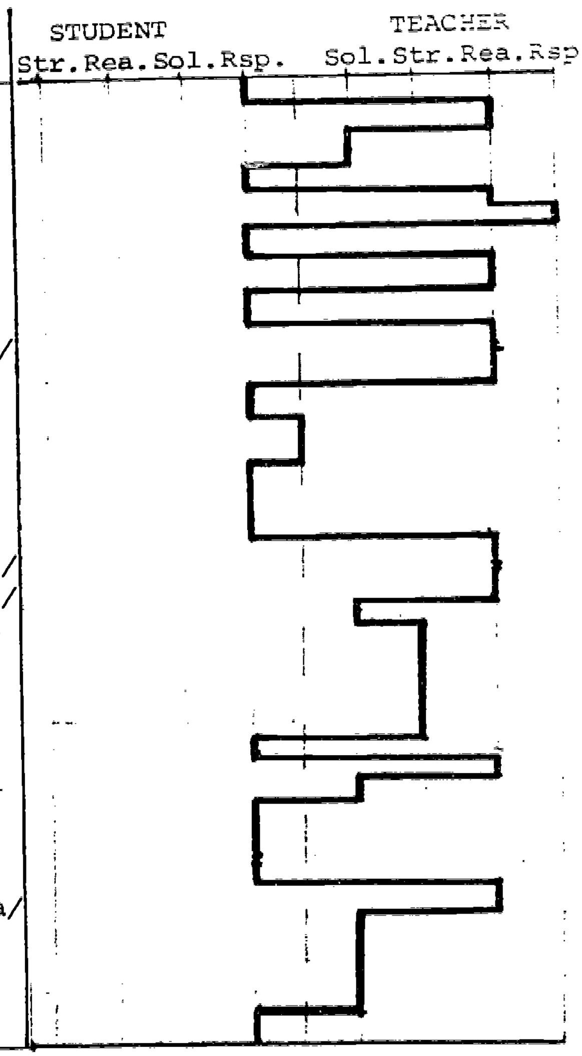
FIGURE VI. A typical analysis of a transcript illustrates the high incidence o
Experime.t: Observing changes in a thermal system.

Item	Repeat	Reward	Fifth Grade	Time	STUDENT Str.	Rea.	Sol.	Rsp.	Wai tim
1			Cl: Ice is melting.					1	
2	1		T : *The* ice is melting. *What do we mean by melting?*						
3			Cl,C2: Getting smaller,					1	
4	1	1	T: Getting smaller, *very good.*						
5			C2: Shrinking					1	
6	1		T: Shrinking						
7			C2: The ice is reducing.					1	
8	2	1	T: The ice is reducing, *that's a good word, S,* reducing.						
9			Cl: *And water is dripping and the ice..(inaudible)*	15 sec				1	1-
10			C2: *Oh, I know what happens, Well, when the ice is dripping it causes* water vapor.					1	
11	2	2	T; Water vapor, *good, that's very, very good.* Water vapor. *what else? You both are looking at the hot bottle, the one with the warm water in it. What about ...(interrupted)*	30 sec					
12			Cl,C2: Hot air, hot air, hot air.					1	
13	1		T: Hot air. *Why is there* hot air?						
14			Cl: *Because there is no space for the new clean air to get in.*					1	
15			C2: *No room* for oxygen.					1	
16	1	1	T: For Oxygen, *that's right, you see the hot air here. (Points to A) What about here?(Points to B)*						
17			C2: *You don't see any.*	45 sec				1	
TOTALS	9	5	45 sec of transcript; average wait time = 0.4 sec.		0	0	0	10	1s

Students = 10

ustrates the high incidence of mimicry and rewarding.
ermal system.

	Time	STUDENT Str.	Rea.	Sol.	Rsp.	Wait time	TEACHER Sol.	Str.	Rea.	Rsp.	
					1						Rsp
							1		1		Rea/Sol
					1						Rsp
d.									1,1		Rea/Rea
					1						Rsp
									1		Rea
					1						Rsp
t's									1,2		Rea/Rea/ Rea
. d	15 sec				1	1+					Rsp
					1						Rsp
ip- or. s apor. look- he one t. What							2	1	2,2		Rea/Rea/ Rea/Sol/ Str/Sol
	30 sec										
air.					1						Rsp
t air?							1			1	Rea/Sol
e for in.					1						Rsp
					1						RRsp
, you ints oints							1	1	1,1		Rea/Rea/ Sol/
	45 sec				1						Rsp
ge wait		0	0	0	10	1sec	5	2	5,9		
		Students = 10					Teachers = 21				TOTAL MOVES



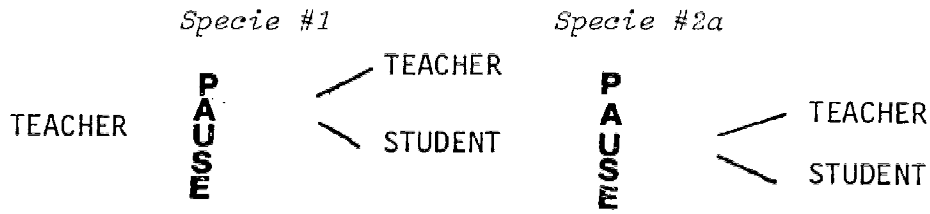


FIGURE 3a. The location of potential pauses in a sequence of moves. As species 2a and 2b increase in length, the probability of S-S-S-S sequences increases.

FIGURE 3b. Pauses in the body of student talk. During explanations, speech from a student often is delivered in bursts or clusters separated by pauses of from two to five or more seconds. (Also see Figure IV.)

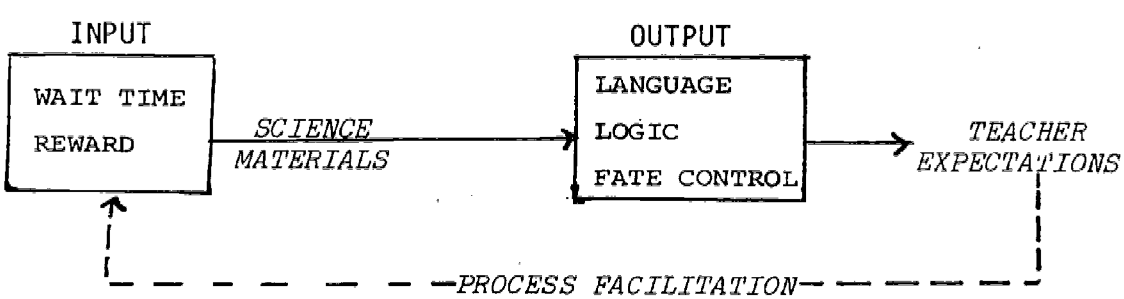
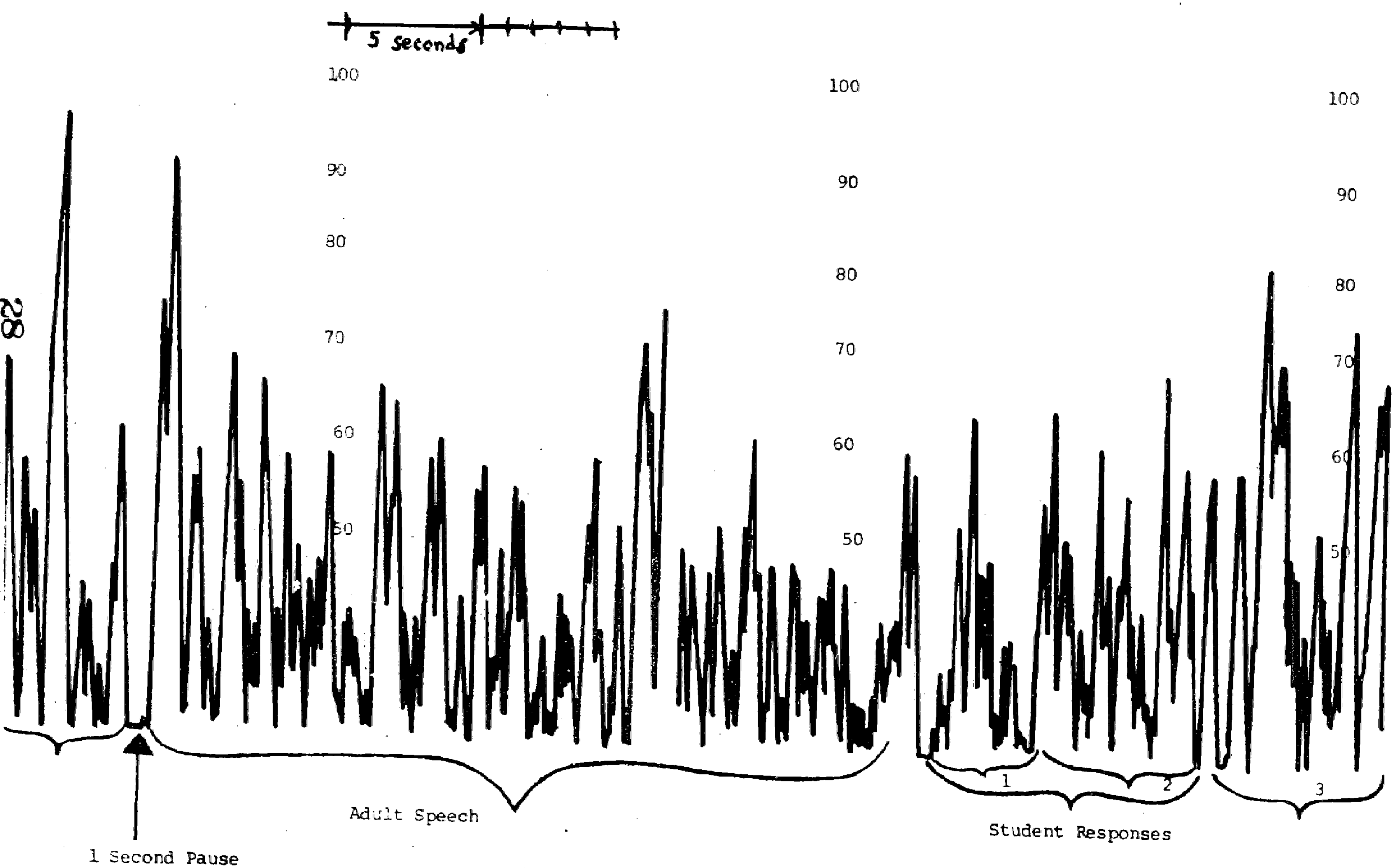


FIGURE 9. Schema of relations between factors.

FIGURE III. Servo-Chart plot of discourse in normal classrooms. Paper is in calibrations whose value is determined by how rapidly it is rolled through the machine. Each interval in this example equals one second.



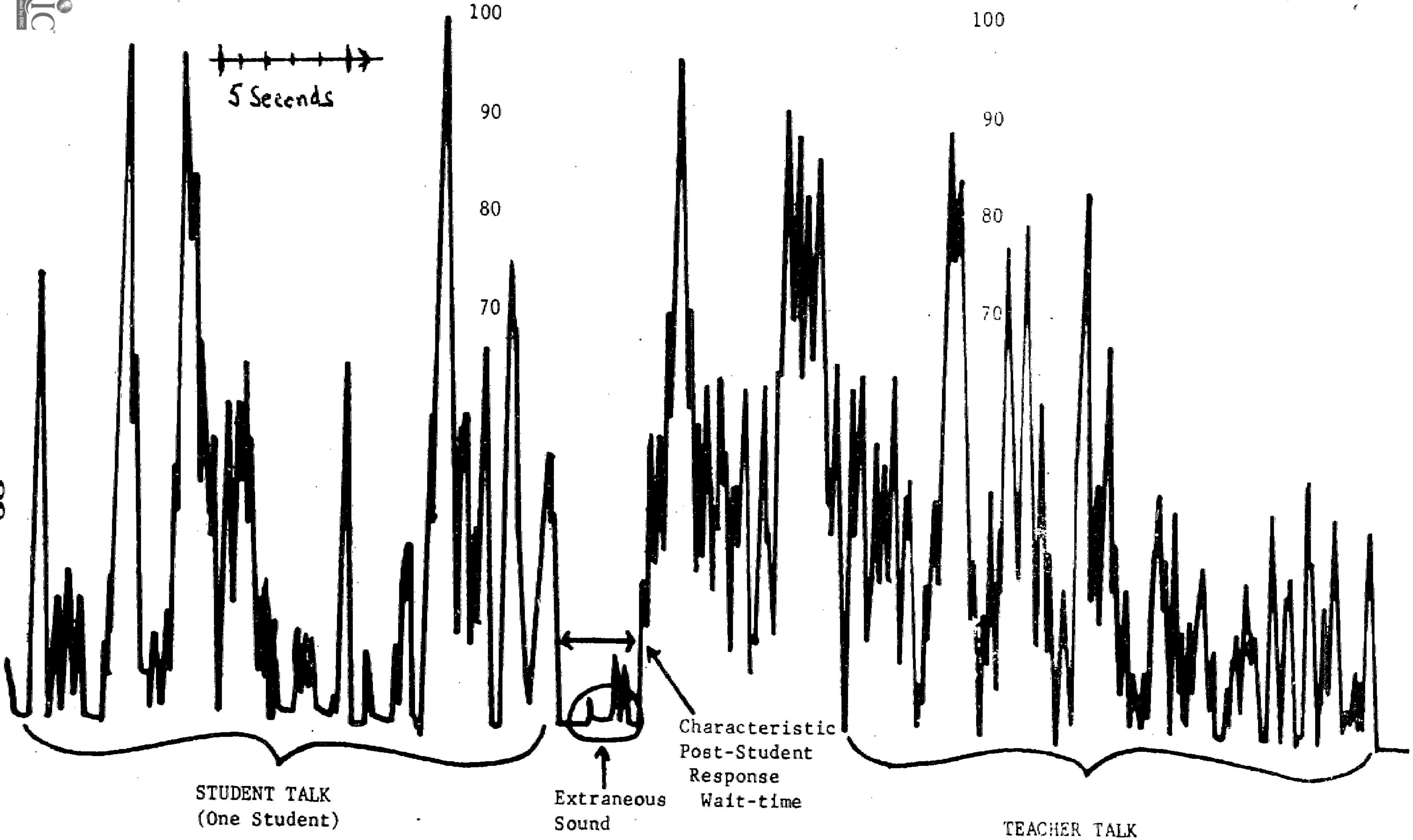


FIGURE IV: Wait-time is increased over that shown in figure III. The area circled indicates a pause which does not appear to be one because the machine picked up the movement of a chair. One of the mechanical problems yet to be solved is to find a way to filter out such events. At the moment they are simply marked on the graph as they happen.

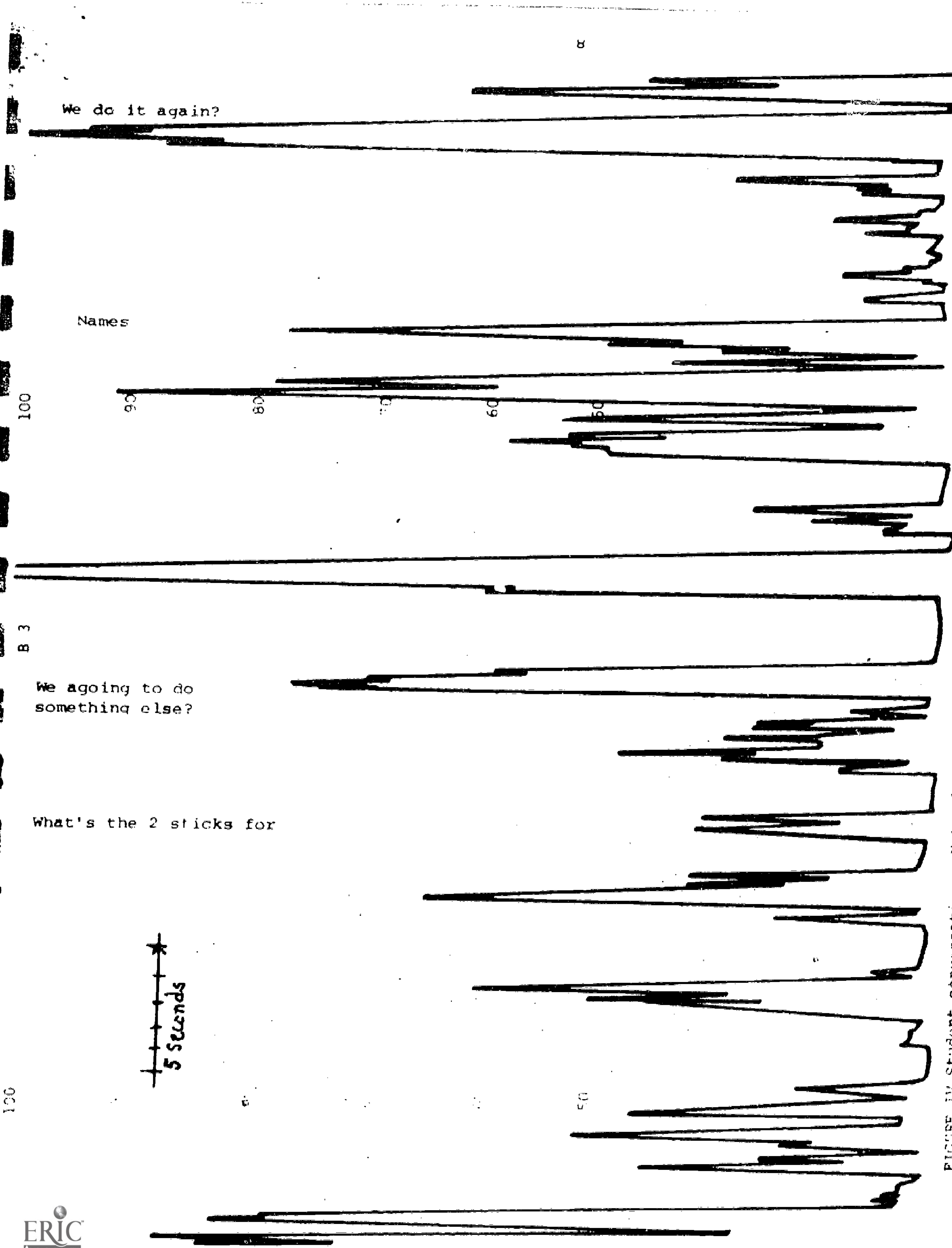
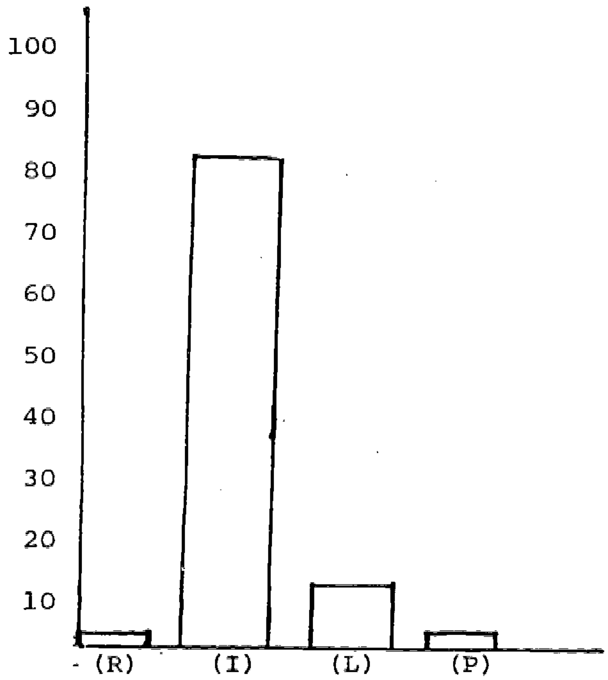


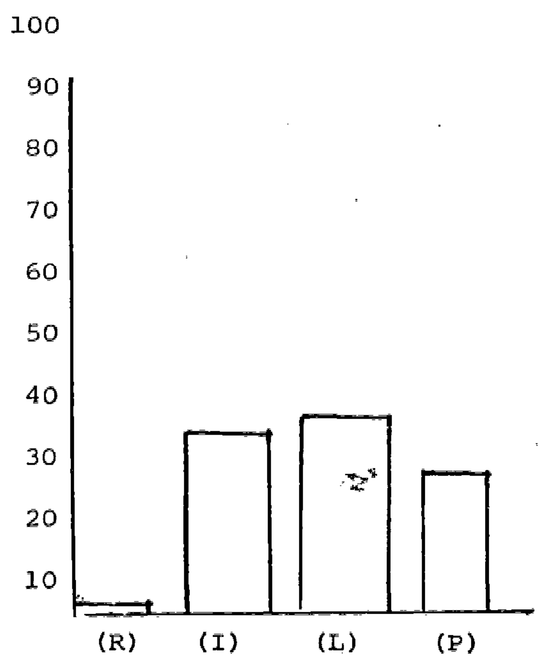
FIGURE IV Student conversation. Note the long pauses. Short wait-times probably interfere with the generation of complete thoughts.



% Rhetorical (R)	3
% Informational (I)	82
% Leading (L)	13
% Probing (P)	2
TOTAL %	100
Mean number of questions per 15 min of transcript	38

N= 95 recordings

FIGURE VII. Typical distribution of question types asked by teachers prior to wait-time training.



% Rhetorical (R)	2
% Informational (I)	34
% Leading (L)	36
% Probing (P)	28
TOTAL %	100
Mean number of questions per 15 min of transcript	8

N = 84 recordings

FIGURE VIIb. Typical change in distribution of question types once criterion wait times of three seconds or more are attained and sustained.

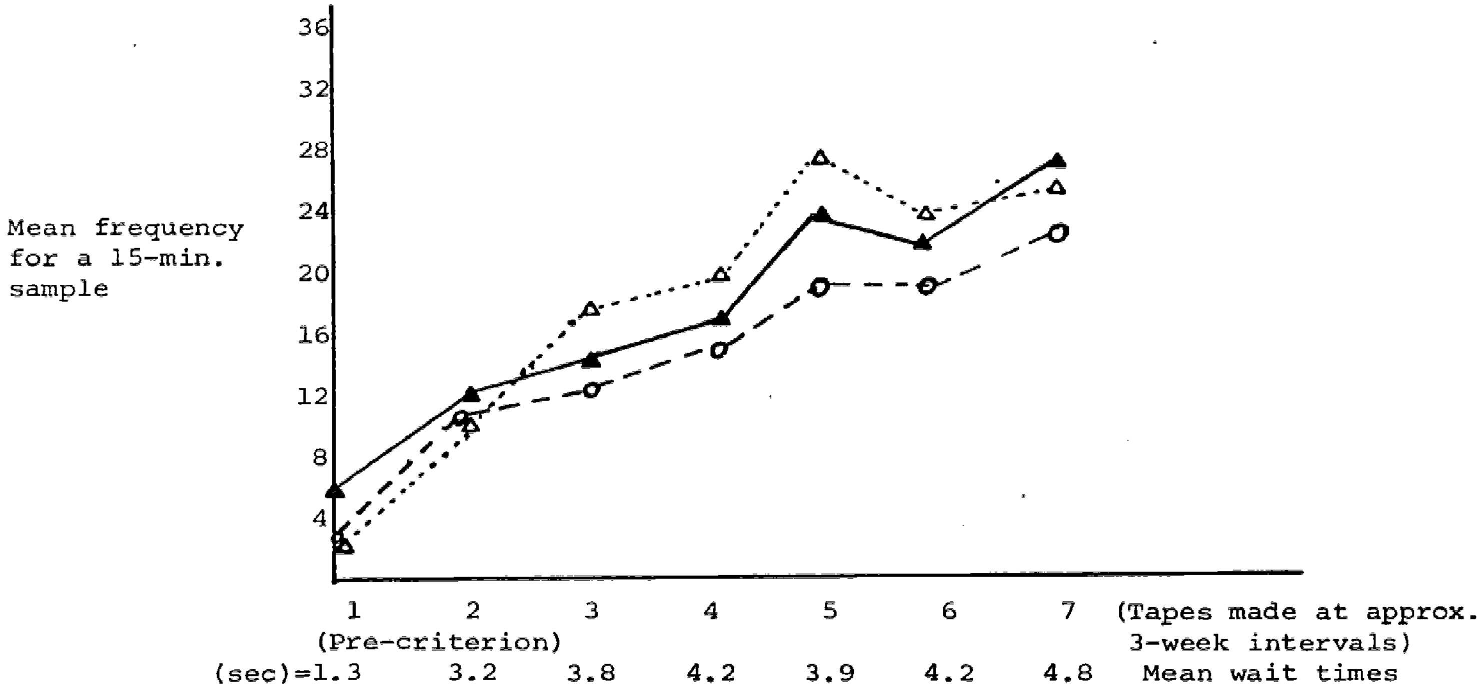


FIGURE VIII. Typical shifts in values of three student outcome variables for a class on a criterion wait-time schedule (Third Grade). ▲ Mean number of solicitations, structuring, and reacting moves; △ mean number of evidence-inference statements; **o** mean length of response.

TABLE I. Student outsome variables: Contrasts between Tape 1 and Tape 6 of the training sequence for 76 out of 95 teachers who achieved criterion wait times of three seconds or longer prior to tape 6.

STUDENT VARIABLES	TAPE 1	TAPE 6
Mean length of response	8	27
range	*(3-12)*	*(14-39 words)*
Mean number of unsolicited but appropriate responses	5	17
range	*(0-17)*	*(12-28)*
Mean number of failures to respond	7	1
range	*(1-15)*	*(0-3)*
Number of evidence-inference statements	6	14
range	*(0-11)*	*(6-21)*
Number of solicitation, structuring, and reacting moves	5	32
range	*(1-8)*	*(11-46)*

15 minutes of tapescript; Tape 1: mean wait time in this sample was 1.2 sec; range 0.8 - 2.4 sec. Tape 2: mean wait time = 3.3 sec; eange = 3.0 - 5.6 sec.